REMARKS

Claims 1-16 have been canceled, and claims 17-37 added. The added claims cover subject matter previously disclosed in the text of the present application as originally filed. Figures 4 and 5 have been revised in only minor respects. The CROSS-REFERENCE TO RELATED APPLICATIONS section, the BACKGROUND OF THE INVENTION section and the BRIEF DESCRIPTION OF THE DRAWINGS section have been amended. The OBJECTIVES OF THE INVENTION section has been added. It does not add new matter, however, because the text contained therein was taken directly from the original summary section. Eight other paragraphs have also been amended. Consequently, no new matter has been added to the present application by virtue of this *Preliminary Amendment*. Procedurally, all of the amendments made herein comport with the requirements of 37 C.F.R. §1.121.

Applicant submits that the application is in condition for allowance. Formal drawing sheets will be submitted upon allowance of the application, unless the Examiner requires them sooner.

I. Drawings

A. Figures 4 and 5

Applicant respectfully requests that the two proposed drawing sheets submitted herewith on which Figures 4 and 5 appear be accepted as substitutes for the sheets of like designation filed with the original application. As originally filed, the text of the

application refers to Figure 4 where it should have referred to Figure 5 and vice versa. It is submitted that the easiest way to correct this problem is to swap figure numbers between the two affected drawing sheets. The revisions appear in red on the proposed drawing sheets, pursuant to 37 C.F.R. §1.121(d).

Approval of the proposed informal drawing sheets is therefore requested. Formal drawing sheets incorporating the proposed changes will be submitted upon allowance of the present application.

II. Specification

Three sections of the application have been amended, and one section added. Specifically, the CROSS-REFERENCE TO RELATED APPLICATIONS section has been revised to identify those prior applications that are related to the present application. The BACKGROUND OF THE INVENTION section has been amended to improve clarity. It was also revised to add a paragraph that was formerly in the SUMMARY OF THE INVENTION section but which is more appropriate for the background section. The BRIEF DESCRIPTION OF THE DRAWINGS section was amended only in minor respects, namely, to correct a grammatical error.

Lastly, the OBJECTIVES OF THE INVENTION section has been added to the application. It does not add new matter to the application, however, as the text added thereto was taken directly from the original summary section. Specifically, it now lists two objectives

of the invention that were formerly in the SUMMARY OF THE INVENTION section but which are more appropriate listed in a separate section.

Approval of the proposed revisions to the specification is therefore respectfully requested.

III. New Claims 17-37 Based On Subject Matter Previously Disclosed in Present and Parent Applications

Applicant respectfully submits that the claims in this *Preliminary Amendment* add no new matter to the present application. The revisions made herein have support in both the present application and the parent application on which it is based. Because MPEP §2163.06 and MPEP §2163.07 are dispositive on this issue, Applicant quotes the relevant sections thereof as follows:

> **MPEP § 2163.06 Relationship of Written Description Requirement To New Matter**
>
> * * * If an applicant amends ... the abstract, specification or drawings of an application, an issue of new matter will arise if the content of the amendment is not described in the application as filed. Stated another way, ***information contained in any one of the specification, claims or drawings of the application as filed may be added to any other part of the application without introducing new matter***. (emphasis added)
>
> **MPEP §2163.07 Amendments to Application Which Are Supported in the Original Description**
>
> Amendments to an application which are supported in the original description are NOT new matter. (emphasis in original)

Applicant respectfully points out that the subject matter recited in new claims 17-37 was described in the present application as originally filed. Specifically, support in the original text for the claimed subject matter can be found between page 7, line 24, and page 11, line 25. In addition, support for the modes of operation as specifically claimed in the dependent claims (i.e., claims 21-26

and 30-34) can be found on page 8, line 7, through page 11, line 14. Support for the mode selection circuitry as claimed in dependent claims 18-20 and 36-37 can be found not only on page 8, lines 10-12 (and page 6, lines 14-17, and page 7, lines 25-27) but also in Figure 2A.

Applicant also points out that the same subject matter was also described in the parent application, i.e., U.S. Application 09/449,255, filed November 24, 1999, now U.S. Patent 6,356,081, granted March 12, 2002. The claimed subject matter also has support in the provisional application on which both the present and parent applications are based, namely, U.S. Provisional Application Serial No. 60/109,820, November 25, 1998.

Based on the foregoing, Applicants respectfully request examination of new claims 17-37.

CONCLUSION

In this *Preliminary Amendment*, the CROSS-REFERENCE TO RELATED APPLICATIONS section, the BACKGROUND OF THE INVENTION section and the BRIEF DESCRIPTION OF THE DRAWINGS section have been amended. The OBJECTIVES OF THE INVENTION section has been added. It does not add new matter, however, because the text contained therein was taken directly from the original summary section. Eight other paragraphs have also been amended. In addition, two revised informal drawing sheets are submitted herewith.

The application as originally filed contained sixteen claims: two independent claims and fourteen dependent claims. Original claims 1-16 have been canceled, and claims 17-37 have been added. Consequently, upon entry of this *Preliminary Amendment*, the application will contain twenty-one (21) claims: two (2) independent claims and nineteen (19) dependent claims. These amendments do not add new matter to the application.

If the Examiner has any questions regarding this *Preliminary Amendment*, he is invited to call the undersigned at the telephone number listed below.

Respectfully submitted,

James R. Stevenson
Attorney for Applicant
Registration No. 38,755

Medrad, Inc.
One Medrad Drive
Indianola, PA 15051-0780
TELEPHONE: (412) 767-2400 x3280
FACSIMILE: (412) 767-8899

APPENDIX I

MARKED-UP COPY OF REVISED PARAGRAPHS OF APPLICATION

(Provided pursuant to 37 C.F.R. §1.121(b)(1)(iii)

PAGE 5: Replace the second full paragraph on page 5 with the amended paragraph that appears below.

FIG. 1 is wire model of a phased array neurovascular coil 50, also referred to herein as a neurovascular array coil. The neurovascular array coil 50 contains four separate imaging coils. The first coil is a quadrature tapered birdcage 60 covering the brain and head. Further details regarding the quadrature tapered birdcage are provided in U.S. Application Serial No. [_____] 09/449,256, [atty ref. 99,443-A,] filed November 24, 1999, now issued as U.S. Patent 6,344,745, the contents of which are incorporated herein by reference. The first coil may alternatively be in the form of a domed birdcage, such as is described in U.S. Patent [No.] 5,602,479, the contents of which are incorporated herein by reference, although the tapered birdcage is preferred because it provides improved field homogeneity on the XZ and YZ image planes.

PAGE 6: Replace the first full paragraph on page 6 with the amended paragraph that appears below.

FIGS. 2A and 2B are electrical schematics of a coil interface circuit 100 that provides multimode operation of the phased array neurovascular coil 50 shown in FIG. 1. The coil interface circuit 100 couples the phased array neurovascular coil 50 to a magnetic resonance imaging (MRI) system. The coil interface circuit 100 has a number of signal input [points] ports 102, which are coupled to receive magnetic resonance (MR) signals from the phased array neurovascular coil 50. As shown in FIG. 2A, signal inputs 102 are coupled to output ports (e.g., port #2, port #3, port #4, port #5, and port #6), which are in turn coupled to predetermined MRI system receivers. Many systems, including the GEMS Signa® MRI system, provide only four receiver channels. Thus, because not all the signal inputs 102 [cannot] can be simultaneously [be] applied to the MRI system [receivers] when the number of potential signal inputs 102 exceeds the number of available receivers, the interface circuit 100 allows selected signal inputs 102 to be coupled to the MRI system receivers.

PAGE 8: Replace the third full paragraph on page 8 with the amended paragraph that appears below.

FIG. 3 is a wire model of the phased array neurovascular coil 50 in NEUROVASCULAR mode. As noted above and shown in FIG. 3, all elements of the phased array neurovascular coil 50 are activated and the MRI system operates in the phased array mode. The NEUROVASCULAR mode may essentially be used for all types of brain and neck imaging[, other than Echo Planar Imaging]. The NEUROVASCULAR mode is particularly useful for brain and/or cervical spine localizers, imaging of the cervical spine, imaging of the carotid arteries, and imaging of the aortic arch. As [The preferred embodiment] shown in FIG. 3, this mode of operation advantageously provides a field of view of up to 46 cm.

PAGE 9: Replace the second full paragraph on page 9 with the amended paragraph that appears below.

FIG. 4 is a wire model of the phased array neurovascular coil in HIGH RESOLUTION BRAIN imaging mode. As shown in FIG. 4, only the quadrature birdcage coil 60 is activated; the cervical spine coils 70 and the anterior neck coils 80 and 90 are electrically disabled. The MRI system operates in phased array mode. The HIGH RESOLUTION BRAIN imaging mode may essentially be used for all types of brain and/or head imaging[, other than echo planar imaging,] but is especially useful for high resolution studies of the brain. The HIGH RESOLUTION BRAIN imaging mode is also useful for high resolution Circle of Willis imaging. As [The preferred embodiment] shown in FIG. 4, this mode of operation provides a field of view of up to 24 cm.

PAGE 10: Replace the second full paragraph on page 10 with the amended paragraph that appears below.

Additional modes of operation for the phased array neurovascular coil 50 [may be used] can be realized by providing the MRI system with the appropriate port masks for the coil interface 100. For example, [embodiments of] the phased array neurovascular coil 50 may also

acquire images [from] when operated in one or more of the following [operational] modes: HIGH RESOLUTION BRAIN AND CERVICAL SPINE, CERVICAL SPINE and VOLUME NECK. Each of these modes is described in further detail below. For these alternative [embodiments] modes of operation, unless otherwise noted, the design of coil interface 100 shall allow [it is assumed that] the cervical spine coils 70 [are] to be applied separately to the coil interface, rather than being combined at the RF level[, and the anterior neck coils 80 and 90 are either combined to provide a single input to the coil interface or replaced by a single anterior neck coil].

PAGE 10: Replace the third full paragraph on page 10, and its associated title, with the amended paragraph that appears below.

HIGH RESOLUTION BRAIN AND CERVICAL SPINE Mode

This mode activates the head and posterior cervical spine coils 60 and 70, and disables the anterior neck coils 80 and 90. This allows focal studies of the brain, brain stem, spinal cord, and cervical spine. The two quadrature components of the MR signal from the birdcage coil 60 each drive a separate receiver channel for optimum uniformity and signal to noise ratio performance. The combiner circuit for birdcage coil 60 is electrically disconnected to allow independent reconstruction of the data from the two channels. Similarly, the [The] two posterior cervical spine coils 70 also each drive a separate receiver channel.

PAGE 10: Replace the fourth full paragraph on page 10, and its associated title, with the amended paragraph that appears below.

CERVICAL SPINE Mode

In CERVICAL SPINE mode, the two quadrature components of the MR signal from each of the two posterior cervical spine coil elements 70 each drive a separate receiver channel for optimum uniformity and signal to noise ratio performance. The head coil element 60 and the anterior neck coils [80,] 80 and 90 are electrically disabled to minimize artifacts and undesirable coil interactions.

PAGE 11: Replace the first full paragraph on page 11, and its associated title, with the amended paragraph that appears below.

VOLUME NECK Mode

This mode disables the tapered birdcage coil 60 covering the head region, and activates the [three] spine region coils to form a volume acquisition of the neck region. The two quadrature components of the MR signal from each of the two posterior cervical spine coil elements 70 and the anterior neck coils 80 and 90 [80, 90] each drive a separate receiver channel for optimum uniformity and signal to noise ratio performance. [In one embodiment] Alternatively, the MR signals from the two posterior cervical spine coils 70 are combined at the RF level and applied as a single input to the coil interface 100, along with the two MR signals from the anterior neck coils 80 and 90. [For embodiments in which the anterior neck coils 80 and 90 are combined at the RF level, the cervical spine coils 70 are combined at the RF level, or only a single anterior neck coil is used, the acquisition uses an unoccupied channel for the fourth channel [GEMS Signa does not directly support a three coil acquisition; Phased Array Data sets must be from one, two, or four receivers].]

APPENDIX II

MARKED-UP COPY OF REVISED SECTIONS OF APPLICATION

(Provided pursuant to 37 C.F.R. §1.121(b)(2)(iii)

CROSS-REFERENCE TO RELATED APPLICATIONS

The invention described in this patent application is closely related to the following patent application: MULTIMODE OPERATION OF QUADRATURE PHASED ARRAY MR COIL SYSTEMS, U.S. Serial No. 09/449,255, filed November 24, 1999, now U.S. Patent 6,356,081, which was granted March 12, 2002. The [This] present application, and the application on which it is based, claim[s] the benefit of U.S. Provisional Application No. 60/109,820, filed November 25, 1998.

BACKGROUND OF THE INVENTION

The advantages of using phased array or multi-coil magnetic resonance (MR) coil systems to enhance magnetic resonance imaging and spectroscopy are well known. A situation facing the designer of such coils is the finite number of available simultaneous data acquisition channels in the host magnetic resonance imaging (MRI) system. [; frequently,] Frequently, there are only four [available] such channels, sometimes known as receivers, available in the host MRI system.

Another issue is the time it takes to reconstruct [reconstruction time to create] the images from the collected data. [; processing] Processing multiple channels to form a single image increases the time needed by the MRI system to process the data, by two or three-dimensional Fourier Transform techniques or other methods, and ultimately to create the final images. Another consideration is [the fact] that data acquisition hardware with additional performance capabilities may only be available on one receiver, or at least on fewer than the total number of available receivers.

Reconstruction of an image from two quadrature modes of a specific phased array coil element via two separate data acquisition channels provides the best possible image signal-to-noise ratio and uniformity, as the data can always be reconstructed in the most optimum way in such a scenario. However, the use of two separate receivers for the two quadrature signals from a specific phased array coil element may cause problems with reconstruction time, or limitations due to the finite number of available receivers. Thus, there may be conditions when combining the two quadrature signals at the radio frequency (RF) level into a single signal may be most advantageous, and other times when processing the two RF signals independently via two separate data acquisition receivers may be the best scheme.

OBJECTIVES OF THE INVENTION

It is, therefore, an objective of the invention to provide a coil interface that allows the two quadrature magnetic resonance (MR) signals from one or more coil elements of a phased array coil system to be acquired as a single signal (combined at the radio frequency (RF) level within the coil interface) by one receiver channel of the host MRI system or as two separate RF signals by two receivers of the MRI system.

Another objective is to provide a coil interface that allows the mode of operation for the phased array coil to be remotely selected from the operator's console of the host MRI system.

SUMMARY OF THE INVENTION

[Reconstruction of an image from two quadrature modes of a specific phased array coil element via two separate data acquisition channels [or receivers] provides the best possible image signal to noise ratio and uniformity, since the data can always be reconstructed in the most optimum way. However, the use of two separate receivers for the two quadrature signals from a specific phased array coil element may cause problems with reconstruction time, or limitations due to the finite number of available receivers. Thus, there may be conditions when combining the two quadrature signals at the RF level into a single signal may be most advantageous, and other times when processing the two RF signals independently via two separate data acquisition receivers may be the best scheme.]

[The present invention allows the two quadrature signals to be acquired as a single signal, precombined at the RF level within the coil interface, or as two separate RF signals by two of the receivers of the phased array hardware. It also provides a means for remote selection of the mode of operation from the operator's console when the system is used with a MRI system, such as the GEMS Signa system.]

In one presently preferred embodiment, the invention provides a coil interface for coupling a phased array coil system to a host magnetic resonance imaging (MRI) system. The host MRI system has a number of receiver channels for receiving magnetic resonance (MR) signals, and the phased array coil system has a plurality of coil elements. The coil interface comprises a plurality of input ports, a plurality of output ports, and an interface circuit. The input ports are adapted to be coupled to the plurality of coil elements. The output ports are adapted to be coupled to the receiver channels of the host MRI system. The interface circuit allows selective interconnection of at least two of the input ports to at least one of the output ports, thereby allowing the phased array coil system to be selectively

operated through the host MRI system in any one of a plurality of operational modes during an MRI scanning procedure.

In a related aspect, the invention provides a method of operating a phased array coil system in a plurality of operational modes. The phased array coil system has a plurality of coil elements capable of operating with a host magnetic resonance imaging (MRI) system during an MRI scanning procedure. The method comprises the steps of providing and selectively configuring an interface circuit. The former step involves providing an interface circuit that has (i) a plurality of input ports for coupling to the coil elements and (ii) a plurality of output ports for coupling to a number of receiver channels of the host MRI system. The later step involves remotely configuring the interface circuit to selectively interconnect at least two of the input ports to at least one of the output ports, thereby allowing the phased array coil system to be selectively operated through the host MRI system in any one of the operational modes during an MRI scanning procedure.

BRIEF DESCRIPTION OF THE DRAWINGS

The preferred embodiments of the present invention are illustrated by way of example, and not limitation, in the figures of the accompanying drawings, in which:

FIG. 1 is a wire model of a phased array neurovascular coil;

FIGS. 2A and 2B are electrical schematics of a coil interface circuit that provides multimode operation of the phased array neurovascular coil shown in FIG. 1;

FIG. 3 is a wire model of the phased array neurovascular coil in a first operational mode;

FIG. 4 is a wire model of the phased array neurovascular coil in a second operational mode; and

FIG. 5 is a wire model of the phased array neurovascular coil in a third operational mode.

F I G. 4

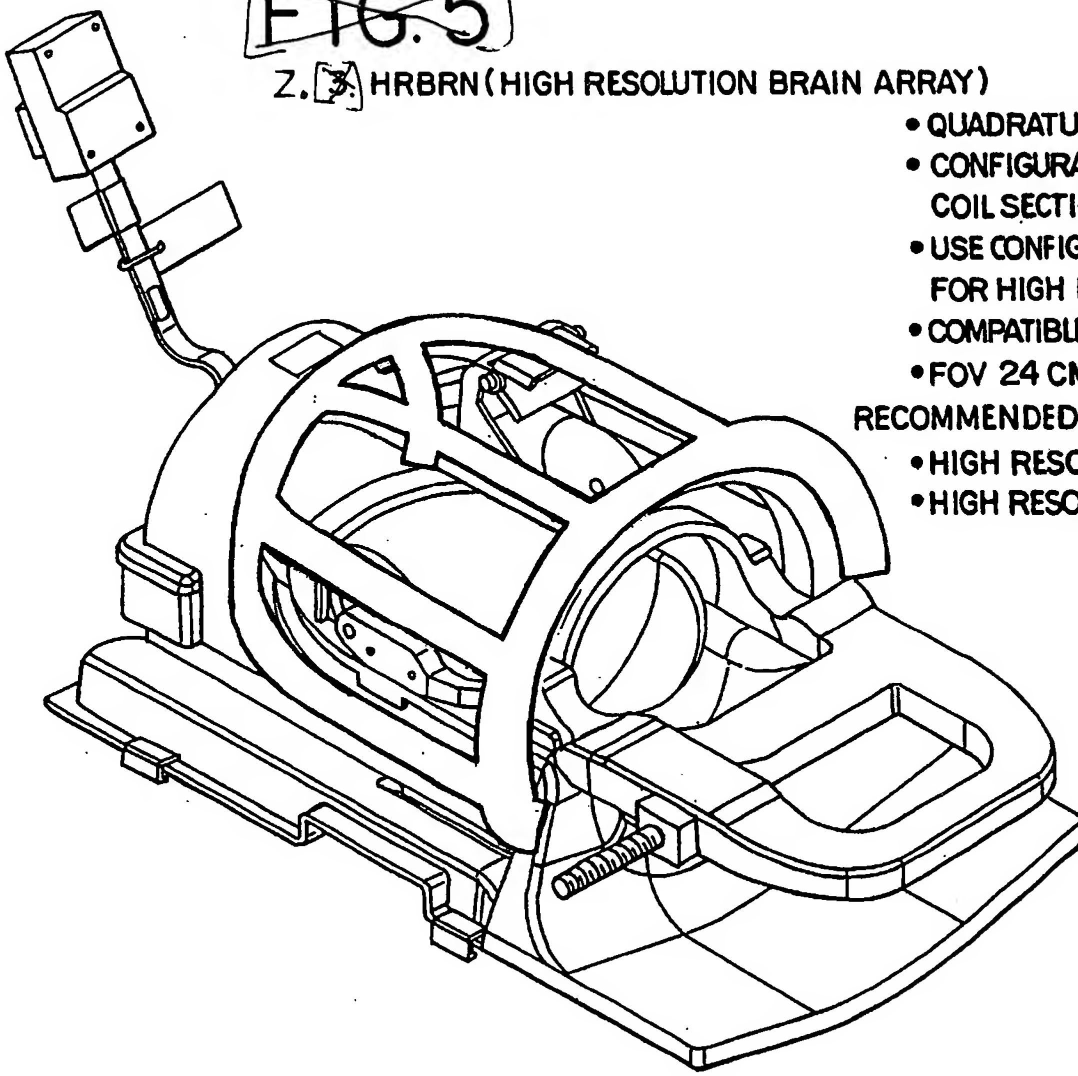
~~FIG.5~~

Z. ~~3.~~ HRBRN (HIGH RESOLUTION BRAIN ARRAY)

- QUADRATURE/PHASED ARRAY MODE
- CONFIGURATION FILE WILLTURN ON ONLY THE HEAD COIL SECTION OF THE ARRAY
- USE CONFIGURATION WHEN IMAGING THE BRAIN FOR HIGH RESOLUTION
- COMPATIBLE WITH ALL IMAGING SEQUENCES, EXCEPT EPI
- FOV 24 CM

RECOMMENDED USES:

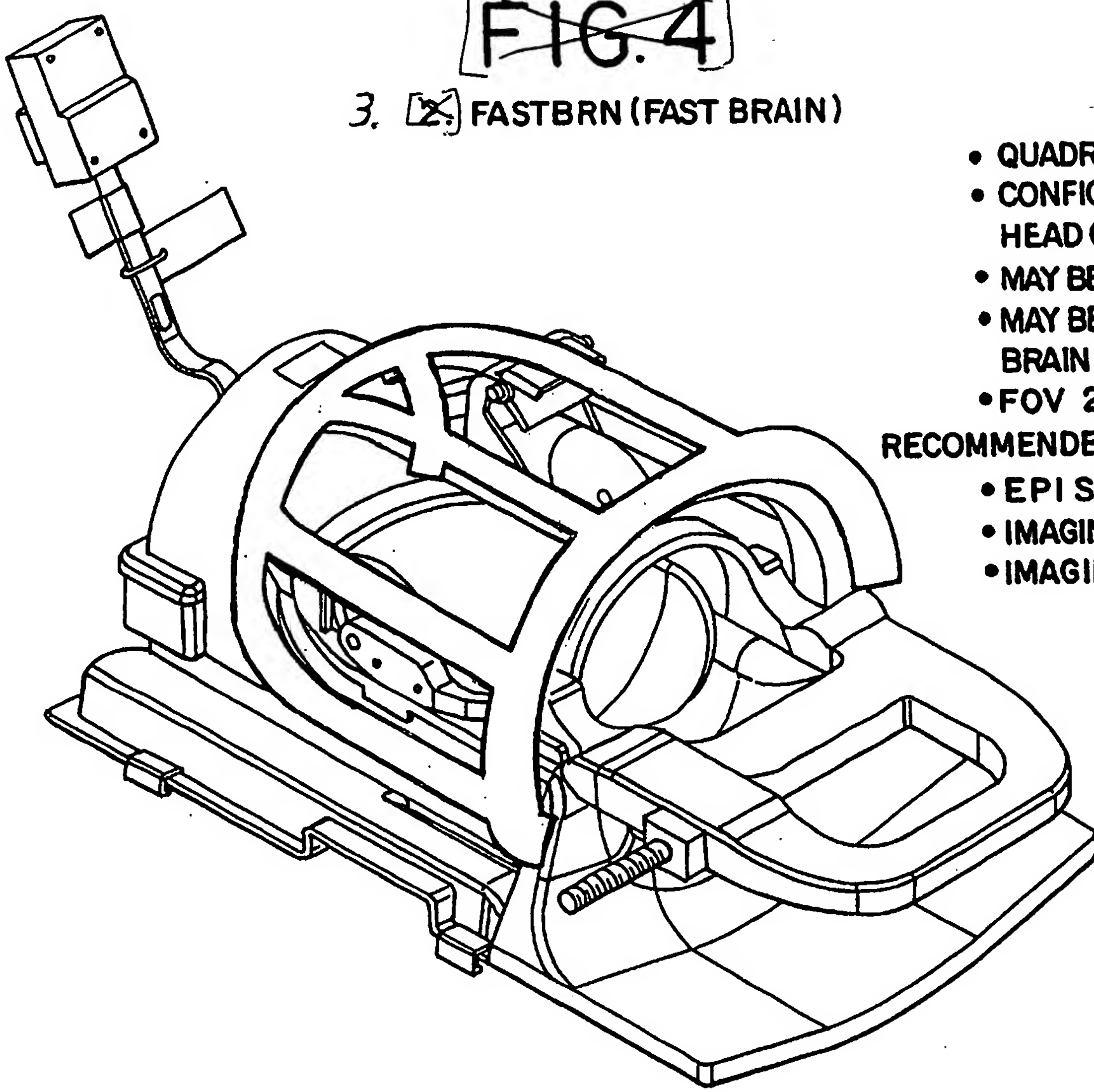
- HIGH RESOLUTION BRAIN IMAGING
- HIGH RESOLUTION CIRCLE OF WILLIS IMAGING



F I G. 5

~~FIG. 4~~

3. ~~2.~~ FASTBRN (FAST BRAIN)



- QUADRATURE MODE
- CONFIGURATION FILE WILL TURN ON ONLY THE HEAD COIL SECTION OF THE ARRAY
- MAY BE USED FOR ECHO PLANAR IMAGING (EPI)
- MAY BE USED FOR VASCULAR STUDIES OF THE BRAIN TO REDUCE RECON TIME
- FOV 24 CM

RECOMMENDED USES:

- EPI SEQUENCES
- IMAGING OF THE BRAIN
- IMAGING OF CIRCLE OF WILLIS